CFRSL

TRMM Microwave Imager Emissive Main Reflector Correction for 1B11 V08

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Abstract

The 17-year time series of TMI precipitation measurements is an important climate record. Since the upcoming TMI 1B11 version-8 will be the legacy brightness temperature (Tb) data product, it is crucial to have a transparent counts-to-Tb algorithm based upon rigorous physical principles. This Tb product will be used to establish the inter-satellite radiometric calibration between TMI/GMI that is the basis for extending the TRMM precipitation measurements into the GMI era. However, the Tb calibration of the TMI is compromised because of an issue with the reflector antenna, and this paper deals with an improved correction developed by CFRSL.

TMI Emissive Reflector Issue

- Since launch, TMI's Tbs has been degraded by a slightly emissive main reflector antenna

$$Tb_{measured} = (1-\varepsilon)Tb_{scene} + \varepsilon T_{physical}$$

where

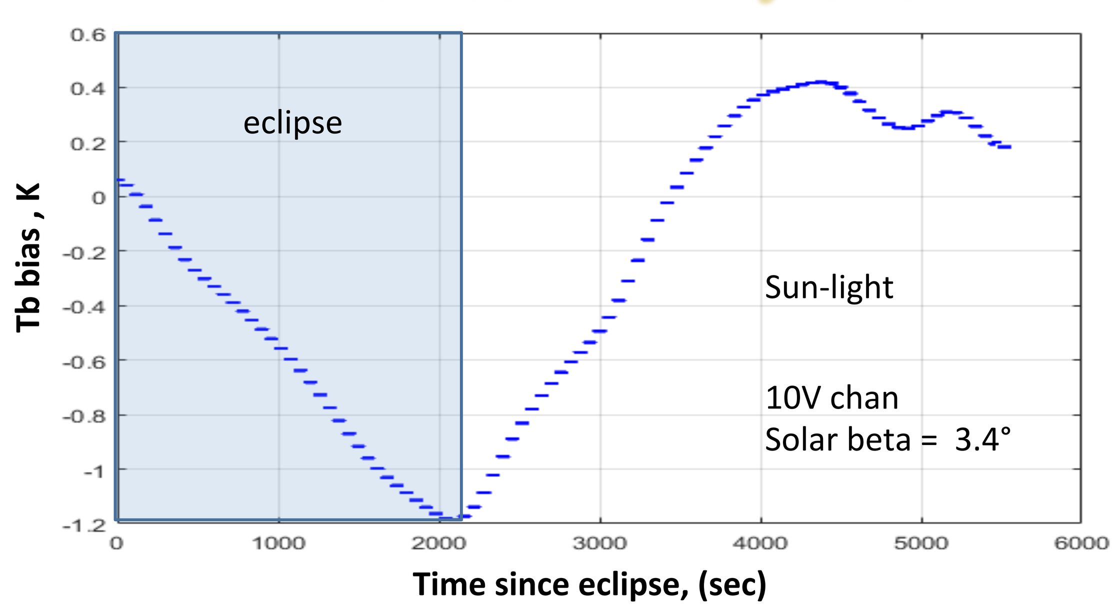
– ε is the reflector emissivity (~ 0.03)

– Tb_{scene} is the desired surface brightness temp

– T_{phy} is the reflector temperature (not measured)

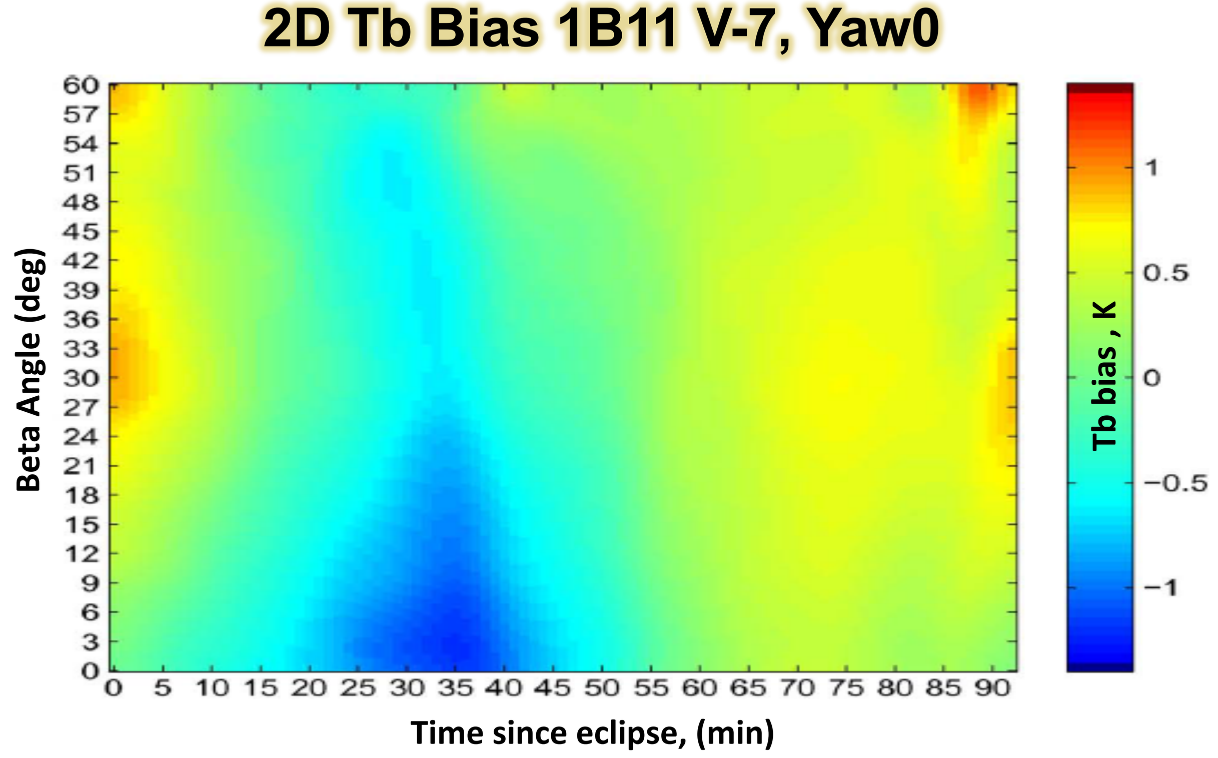
- This resulted in a time-varying radiometric calibration error of ± 0.75 K over one orbit and ± 1.5 K over seasons for all channels (freq/pol)

1DTb Bias 1B11 V-7, Yaw0

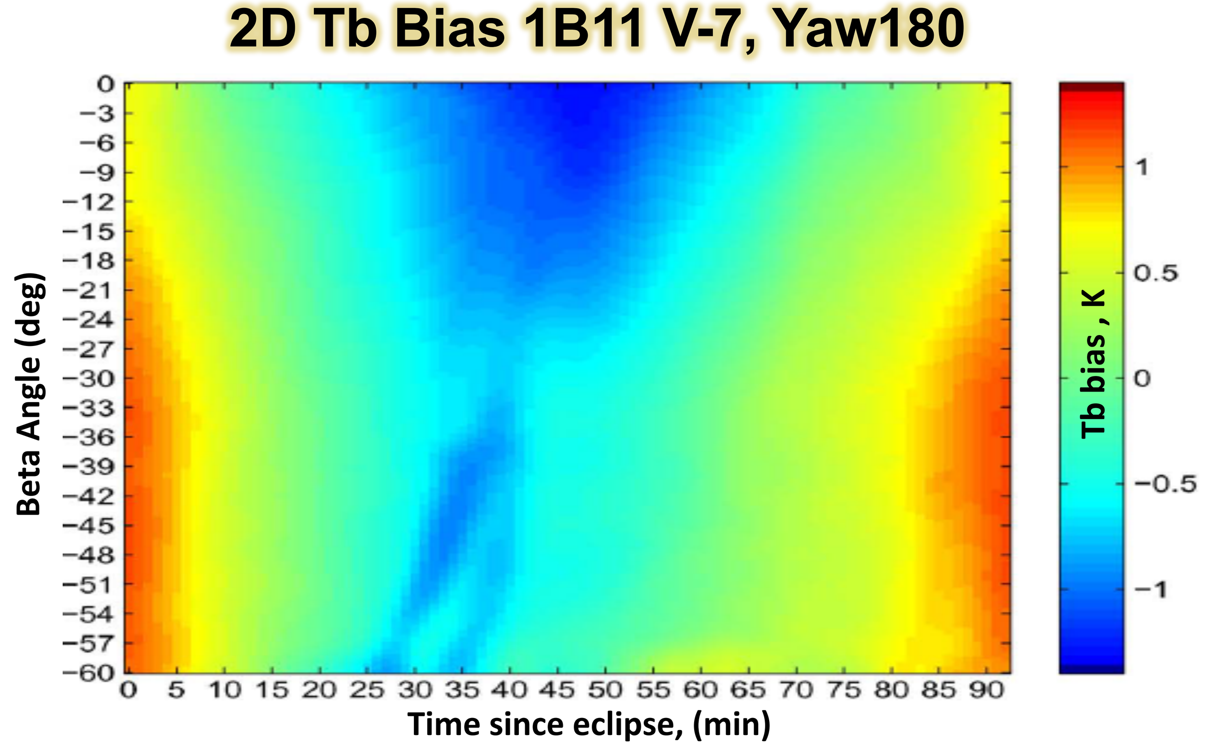


- In 2009, this issue was identified & an ad-hoc correction applied in the 1B11 V-7
- Tb Bias = f(solar beta ang, time since eclipse, yaw)

2D Tb Bias 1B11 V-7, Yaw0

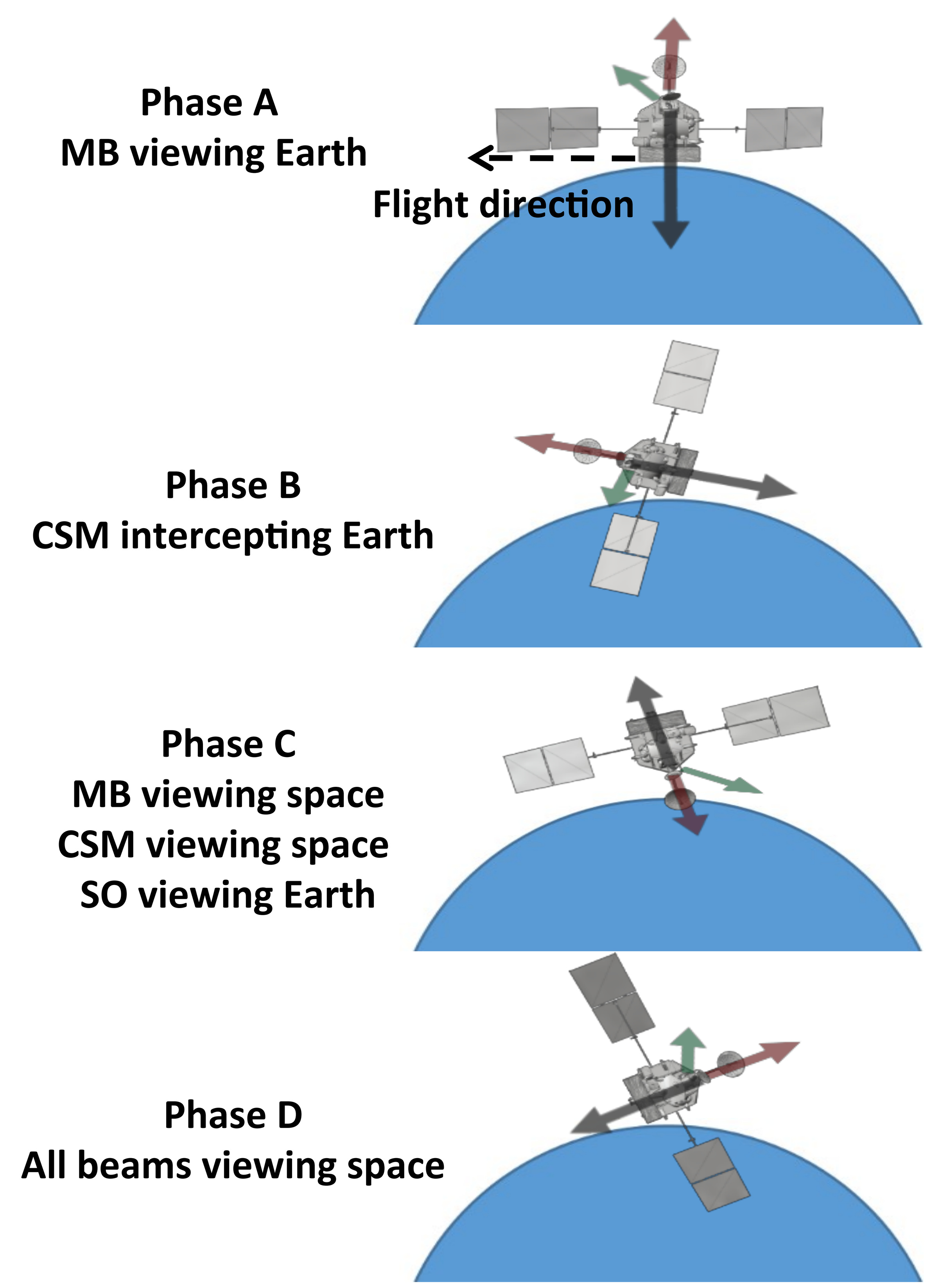


2D Tb Bias 1B11 V-7, Yaw180



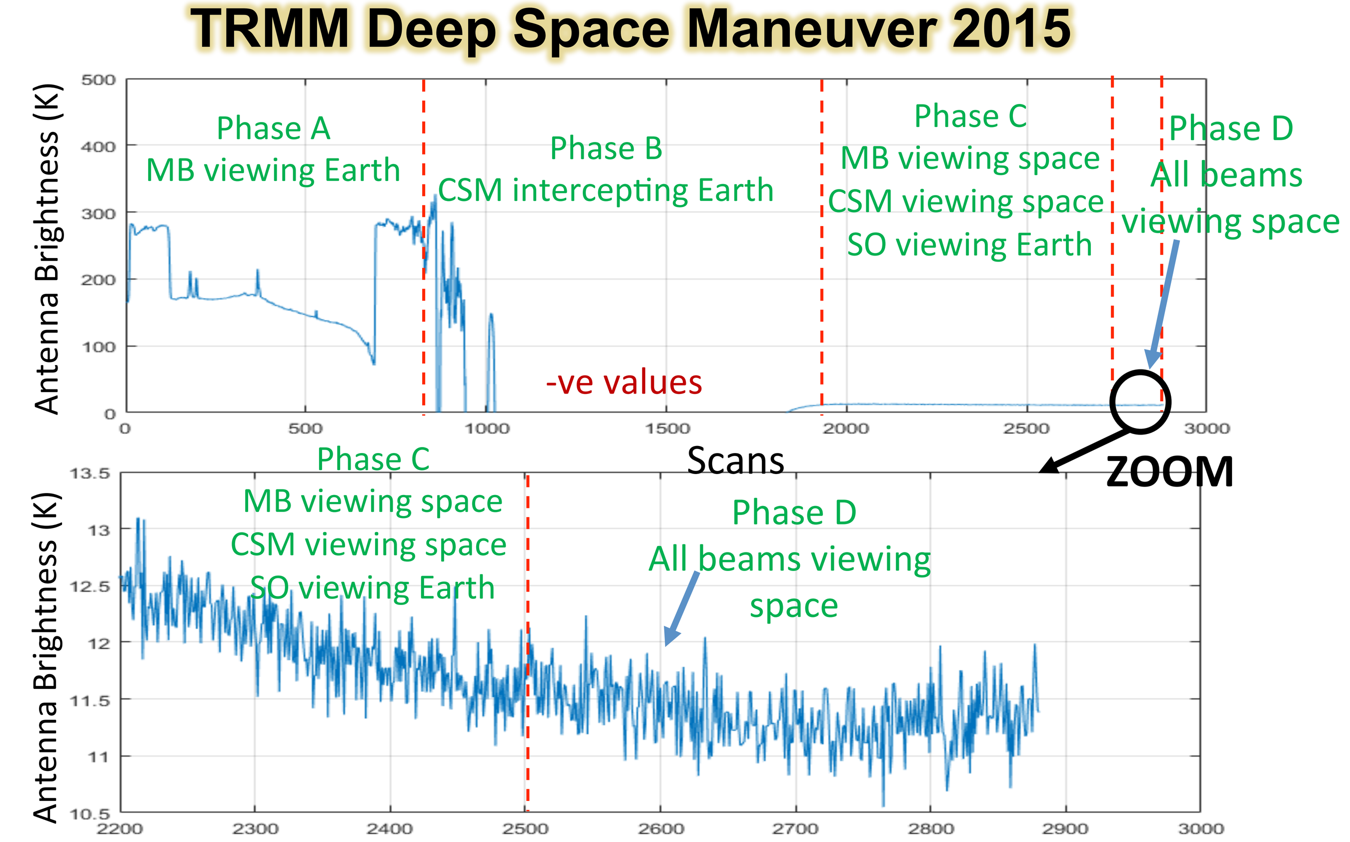
Deep Space Calibration (DSC) Maneuvers for TMI 1B11 V8

- During 2015, an improved DSC maneuver was performed
  - TRMM yaw attitude = 90°and roll attitude completed 360°rotation during one orbit
  - Thus causing TMI antenna to view "cold space" brightness temperature = 2.73 Kelvin
  - TMI antenna system comprises 3 beams:
    - Main Beam (MB) black vector, Spill-Over (SO) red vector, and Cold Sky Mirror (CSM) green vector



- This DSC maneuver resulted in all beams viewing space simultaneously, which is best for radiometric calibration

TRMM Deep Space Maneuver 2015

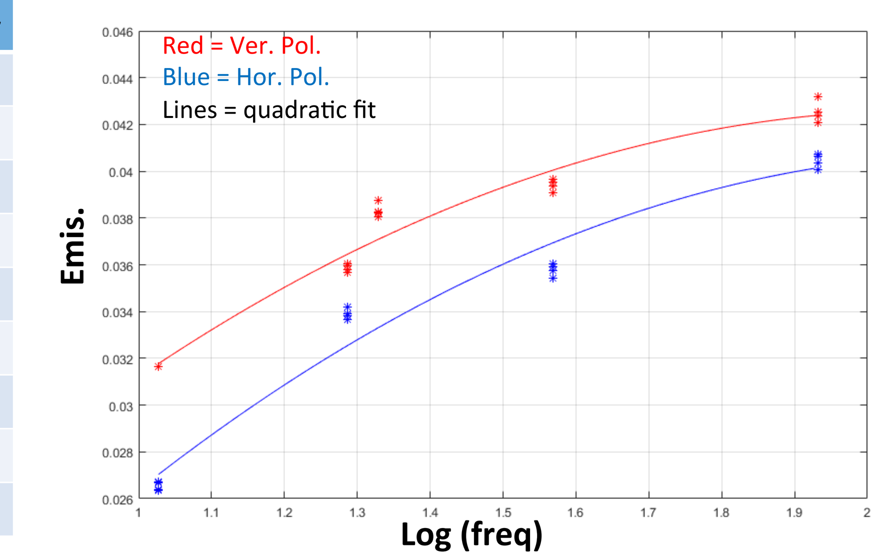


Emissivity derivation

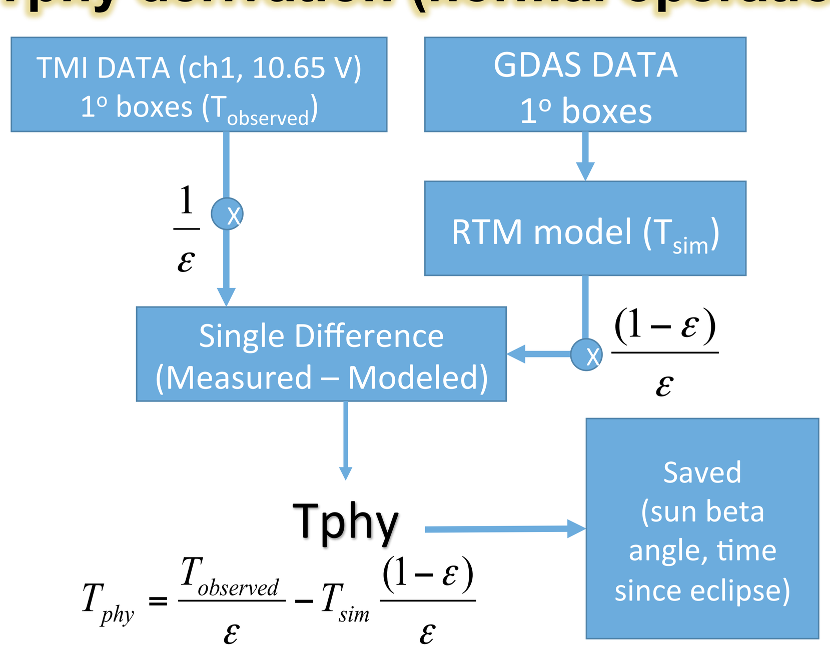
- GMI's measured reflector physical temperature, at the same sun beta angle and time since eclipse, was used to derive channel emissivities

$$\varepsilon_i = \frac{<T_A> - 2.73}{(1-\eta_i)*(T_{phy} - 2.73)}$$

Channel	CFRSL emissivity
10.65 V	0.03163
10.65 H	0.02654
19.35 V	0.03586
19.35 H	0.03390
21.30 V	0.03832
37.00 V	0.03940
37.00 H	0.03680
85.50 V	0.04253
85.50 H	0.04045

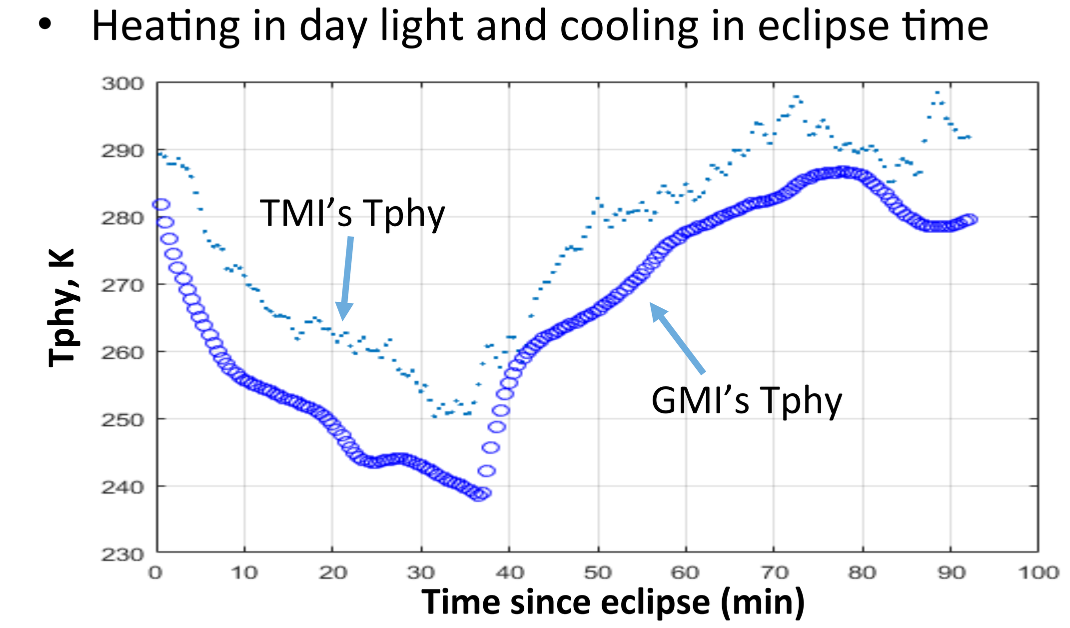


Tphy derivation (normal operation)

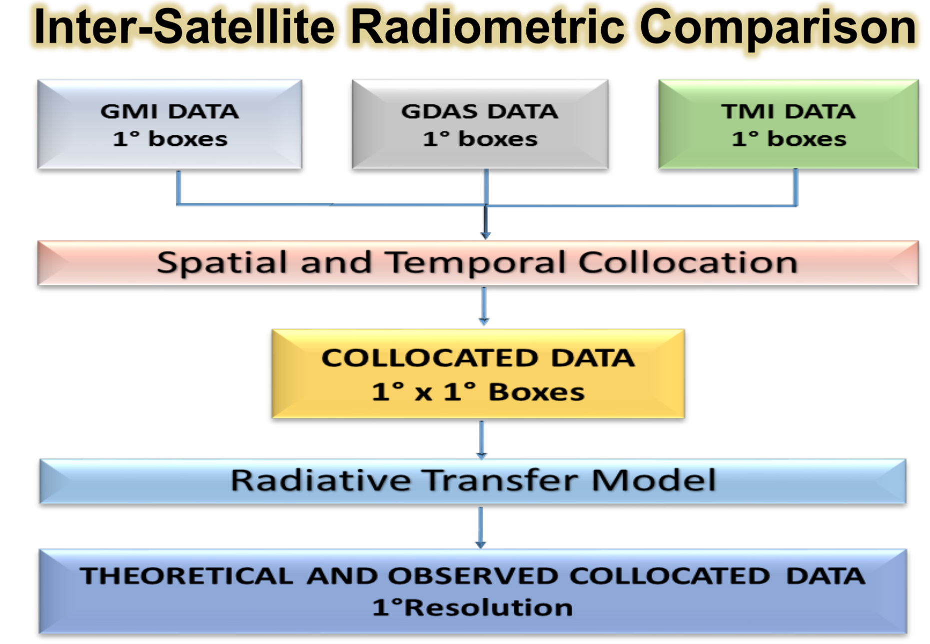


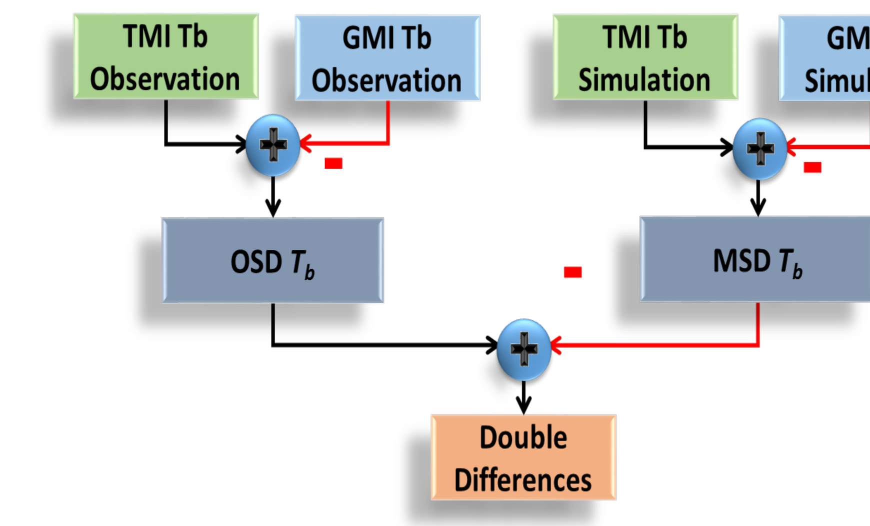
Computed TMI's Tphy and measured GMI's Tphy Comparisons

- TMI and GMI have similar spinning reflector antennas, but they operate in different orbits
- However, at an identical solar beta angle, they experience comparable solar heating environment
  - Heating in day light and cooling in eclipse time



Inter-Satellite Radiometric Comparison





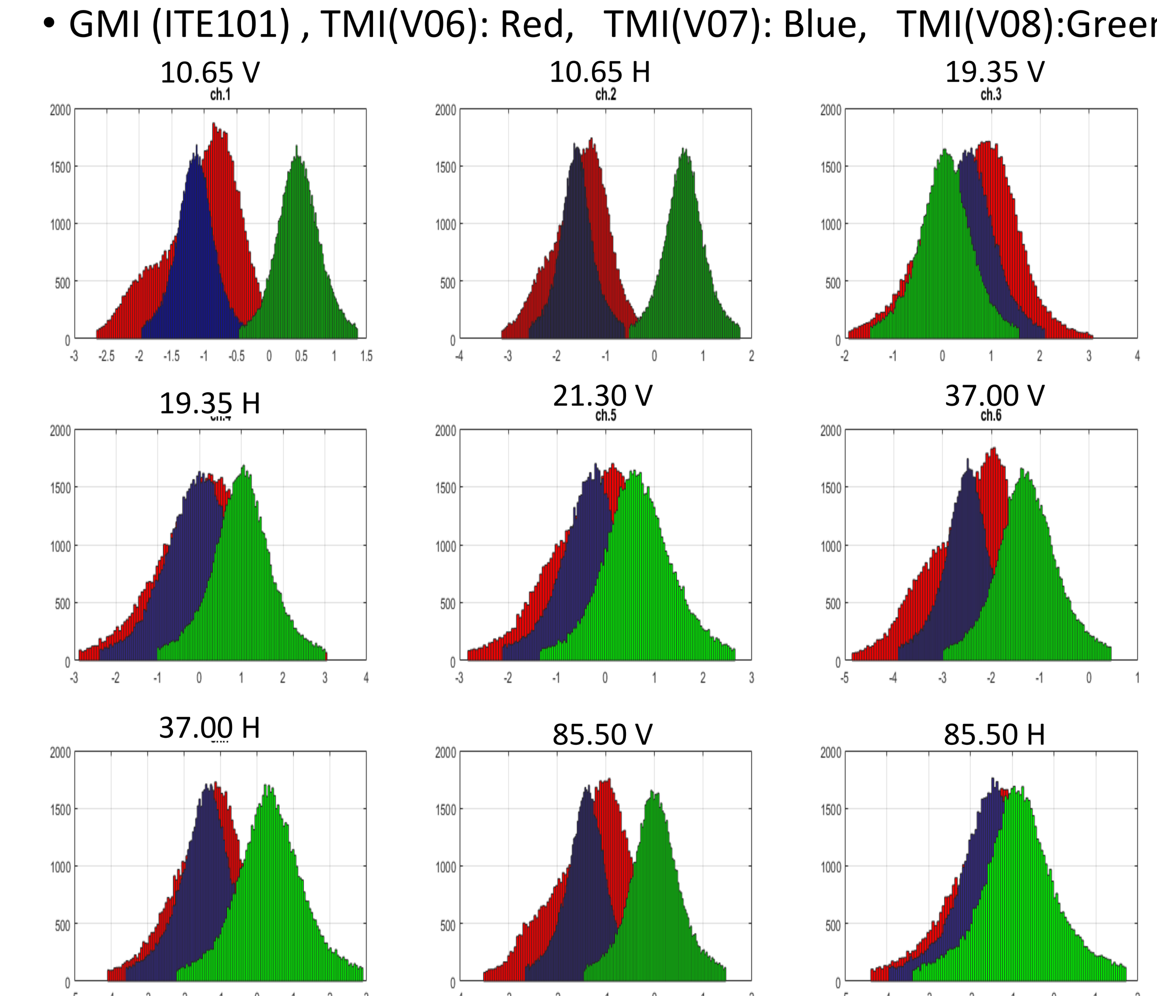
Modeled Single Difference: $MSDT_b = (T_{b\_TMI\text{-}sim} - T_{b\_GMI\text{-}sim})$

Observed Single Difference: $OSDT_b = (T_{b\_TMI\text{-}obs} - T_{b\_GMI\text{-}obs})$

Double Difference: $DD = OSDT_b - MSDT_b$

DD TMI (V8) & GMI (ITE101) (Yaw0,2014)

- GMI (ITE101) , TMI(V06): Red, TMI(V07): Blue, TMI(V08):Green



What's New in TMI 1B11 V8?

- The TMI 1B11 V7 brightness temperature record, incorporates a number of ad hoc adjustments, made over the sensor lifetime to improve the radiometric calibration
- For the 1B11 V8, the XCAL working group has developed an improved radiometer counts-to-Tb radiative transfer model based upon strict physical principles and upon the reanalysis of on-orbit "Deep Space Calibration" (DSC) maneuvers
  - In 1998, several DSC test were performed by pitching the spacecraft to cause the antenna system to view the uniform brightness of space
    - Unfortunately, the design of the DSC was flawed and the data analysis yielded inaccurate results
  - In 2015, prior to end of the TRMM mission, a new DSC was conducted by performing a spacecraft maneuver of yaw = 90° followed by a 360° roll
    - This DSC allowed the TMI 3-antenna beams to simultaneously view space and thereby to derive a correction for the effects of an emissive main reflector
  - Analysis of these data forms the basis of the new 1B11 V8, which will be available in summer 2017